A preliminary survey of the freshwater mussels (Unionidae) of the Nottawasaga River watershed

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TABLE OF CONTENTS

ABSTRACT v

RÉSUMÉ v

1.0 INTRODUCTION 1

2.0 METHODS 2

3.0 RESULTS 3

3.1 ABIOTIC FACTORS 3

3.2 FRESHWATER MUSSEL COMMUNITY 3

4.0 DISCUSSION 5

4.1 *ELLIPTIO DILATATA* (SPIKE) AND *ELLIPTIO COMPLANATA* (EASTERN ELLIPTIO) 5

5.0 CONCLUSION 5

6.0 ACKNOWLEDGEMENTS 7

7.0 REFERENCES 8

LIST OF TABLES

Table 1. Mussel species occurring in the Nottawasaga River. 10

Table 2. Physical characteristics of the sites surveyed in the Nottawasaga River watershed in 2009. 11

Table 3. Number of live specimens collected at each of the 23 sites surveyed in the Nottawasaga River watershed in 2009 by Fisheries and Oceans Canada 12

Table 4. Abundance and frequency of occurrence of all mussel species observed in the Nottawasaga River watershed in 2009. 13

LIST OF FIGURES

Figure 1. Location of the Nottawasaga River watershed as well as the Maitland and Ausable rivers 14

Figure 2. Twenty-six sites surveyed in July 2009 on the Nottawasaga River, Willow and Innisfil creeks, and the Boyne, Pine, and Mad rivers. 15

Figure 3. Length frequency distribution of male (n = 201) and female (n = 69) *Lampsilis siliquoidea* (Fatmucket) found and sexed in the Nottawasaga River watershed in 2009 16

Figure 4. Length frequency distribution of *Elliptio dilatata* (Spike) found in the Nottawasaga River watershed in 2009 (n = 70). 17

Figure 5. *Elliptio complanata* (top four specimens) and *Elliptio dilatata* (bottom four specimens) found at site NR1-1 in Wasaga Beach in the Nottawasaga River watershed on July 7, 2009. 18

Figure 6. Map of Canadian waterbodies demonstrating the geographic range of *Elliptio complanata*, an Atlantic Slope species found in the Nottawasaga River watershed in July 2009. 19

Figure 7. Map of Canadian waterbodies demonstrating the geographic range of *Elliptio dilatata*, a Mississippian species found in the Nottawasaga River watershed in July 2009 20

LIST OF APPENDICES

Appendix A. Locations of all sites identified and surveyed in Nottawasaga River watershed in 2009 by Fisheries and Oceans Canada. 21

ABSTRACT

Minke-Martin, V., Morris, T.J., and McNichols-O'Rourke, K.A. 2012. A preliminary survey of the freshwater mussels (Unionidae) of the Nottawasaga River watershed. Can. Manuscr. Rep. Fish. Aquat. Sci. 2994: v + 22 p.

Fisheries and Oceans Canada, in cooperation with the Ontario Freshwater Mussel Recovery Team, and the Nottawasaga Valley Conservation Authority conducted a survey of the freshwater mussels (Unionidae) of the Nottawasaga River watershed in July 2009. This watershed represented the last large watershed in southwestern Ontario to be systematically surveyed for unionids. Twenty-three sites were sampled along the main channel and its tributaries, the Boyne and Pine rivers, and Innisfil and Willow creeks. A total of 581 animals were found, representing 11 different species. The dominant species in the watershed was *Lampsilis siliquoidea*, which made up 56% of all mussels found and was present at 43% of the sites surveyed. No federally or provincially listed Species at Risk were detected at any of the sites. The Nottawasaga River represents an important river from a biogeographic standpoint, as it is the only place in southwestern Ontario where both *Elliptio complanata* (an Atlantic Slope species) and *Elliptio dilatata* (a Mississippian species) are known to co-occur.

RÉSUMÉ

Minke-Martin, V., Morris, T.J., and McNichols-O'Rourke, K.A. 2012. A preliminary survey of the freshwater mussels (Unionidae) of the Nottawasaga River watershed. Can. Manuscr. Rep. Fish. Aquat. Sci. 2994: v + 22 p.

Pêches et Océans Canada, en collaboration avec l'Équipe de rétablissement de la moule d'eau douce de l'Ontario et la Nottawasaga Valley Conservation Authority ont effectué une étude sur les moules d'eau douce (*Unionidae*) du bassin hydrographique de la rivière Nottawasaga en juillet 2009. Ce bassin hydrographique constituait le plus grand bassin versant de toute la région sud-ouest de l'Ontario dans lequel on a étudié de façon systématique les unionidés. Vingt-trois sites ont été échantillonnés le long du chenal principal et de ses affluents, les rivières Boyne et Pine de même que les ruisseaux Innisfil et Willow. On a recensé au total 581 individus, représentant 11 espèces différentes. L'espèce dominante du bassin hydrographique était la *Lampsilis siliquoidea* qui représentait 56% de toutes les moules recensées; elle a été retrouvée dans 43% des sites étudiés. Aucune espèce en péril, reconnue comme telle au niveau fédéral ou provincial, n'a été détectée dans aucun des sites. La rivière Nottawasaga constitue une importante rivière d'un point de vue biogéographique, car c'est le seul endroit du sud-ouest de l'Ontario où l'on observe simultanément la présence d'*Elliptio complanata* (une espèce de la pente atlantique continentale) et d'*Elliptio dilatata* (une espèce du Mississipi).

1.0 INTRODUCTION

Ontario has the largest representation of freshwater mussels in Canada, with 41 species native to the province; however, more than 65% of Ontario's native species are showing signs of decline (Metcalfe-Smith et al. 2005). Thirteen of these are listed as endangered, threatened, or as a species of special concern under the provincial *Endangered Species Act* (OMNR 2012). This trend is reflected across the continent, with an estimated 72% of North American species considered threatened, endangered or extinct (Williams et al. 1993). In spite of population declines, freshwater mussels have significant roles in aquatic ecosystems. They filter particulate matter from the water column, making it available for aquatic and terrestrial organisms; mix and oxygenate the substrate; and provide habitat for small organisms (Vaughn and Hakenkamp 2001, Vaughn and Spooner 2006). Watershed surveys are used to determine the presence of mussel species and monitor the survival and recovery of populations in the Great Lakes basin.

The Nottawasaga River watershed is located on the southern shore of Georgian Bay, in southwestern Ontario (Figure 1). The river, 122 km in length along its main channel, flows from headwaters near Shelburne to the mouth at Wasaga Beach on Georgian Bay. The watershed drains 3,147 km² of the Nottawasaga basin between Collingwood and Lake Simcoe (South Georgian Bay-Lake Simcoe Source Protection Committee 2011). The major tributaries include the Boyne, Pine, and Mad rivers and the Willow, Innisfil, and Cookstown creeks. The Nottawasaga, Mad, and Pine rivers flow down the Niagara Escarpment, and a few small tributaries originate on the Oak Ridges Moraine on the southern boundary of the watershed (NVCA 2008). The basin is characterized by sand, calcareous clay, and marl (Chapman and Putnam 1984). The water table is high in areas, notably in Minesing Wetlands, north of Angus, the third largest wetland in southern Ontario (NCC 2009). The land use is primarily agricultural.

Prior to the sampling described here, little was known about the freshwater mussel fauna of the Nottawasaga River. Fisheries and Oceans Canada's Lower Great Lakes Unionid Database (2011) contains 24 historical records (pre-1998). Nineteen of these records are of museum specimens with little detailed information associated (Table 1). The remaining five records are derived from John Detweiler's 1916 surveys of southern Ontario rivers (Detweiler 1918). Detweiler reportedly visited the Nottawasaga River in August of 1916 accompanied by a Mr. Gross (likely Mr. David Gross, owner of the Dominion Pearl Button Company of Kitchener, Ontario) in an effort to evaluate the economic potential of the river's mussels. By Detweiler's account, only a small portion of the lower river was surveyed, however, the mussel bed was very thick (Detweiler 1918). These combined historical records indicate the presence of 13 species in total though it is likely that three of these (*Anodonta implicata* (Alewife Floater), *Lampsilis radiata* (Eastern Lampsmussel) and *Pyganodon cataracta* (Eastern Floater)) represent erroneous identifications based on the known distributions of these species. Although no Species at Risk (SAR) were found

historically, there are significant populations of SAR in other nearby rivers in the Lake Huron drainage. Populations of the federally endangered *Epioblasma torulosa rangiana* (Northern Riffleshell), *Epioblasma triquetra* (Snuffbox), and *Ptychobranchus fasciolaris* (Kidneyshell) are known from the Ausable River, along with *Lampsilis fasciola* (Wavyrayed Lampmussel), a species of special concern. Ontario's largest population of *Villosa iris* (Rainbow), which has been assessed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), is located in the Maitland River (COSEWIC 2006). The Nottawasaga River was the last large watershed in southwestern Ontario without a formal mussel survey and, given the close proximity to other SAR-containing watersheds, was considered a high priority for a watershed survey by the Ontario Freshwater Mussel Recovery Team.

2.0 METHODS

Two sampling events were undertaken within the Nottawasaga River watershed during the open water season of 2009. The first was carried out by a large team of researchers from Fisheries and Oceans Canada (DFO), the Ontario Freshwater Mussel Recovery Team, and the Nottawasaga Valley Conservation Authority. During this initial survey, carried out in early July 2009, 17 sites were sampled throughout the watershed, with seven on the main channel, one each on Innisfil Creek, Mad River and Pine River, four on Boyne River, and three on Willow Creek. An additional two sites on Pine River and one on Mad River were scouted, but never searched. The second survey was conducted by DFO staff in late July 2009 when an additional six sites, four on the main channel and two on Innisfil Creek, were surveyed (Appendix A). The purpose of the second survey was to extend the geographic scope of the first sampling event, with particular interest in headwater areas.

Each site was surveyed using the intensive timed-search technique of Metcalfe-Smith et al. (2000). At each site the substrate was surveyed to the maximum wading depth using visual (viewing boxes, naked eye) and tactile (excavation using hands and scoops) techniques. A team of at least three people moved parallel to the river bank for a total of 4.5 person-hours of searching per site. During the surveys, all live animals were removed from the substrate and placed in a mesh diver's bag. At the end of the sampling period, mussels from all collectors were combined, identified, measured, and sexed if possible, before being returned to the river.

In addition to biological data, several physical and environmental variables were recorded at each site. These variables included substrate composition, water clarity, length of reach, mean stream depth, and width. Substrate percent cover was visually estimated and the remaining variables were measured using a metre stick. Definitions of substrate sizes used to determine substrate composition were modified from Wentworth (1922): boulder (>250 mm in diameter), rubble (60-250 mm), gravel (20-50 mm), sand (<2 mm) and "other" material (mud, muck, silt, and detritus).

3.0 RESULTS

3.1 ABIOTIC FACTORS

A summary of the physical data collected during the surveys of the Nottawasaga River watershed is presented in Table 2. These data are not meant to address issues relating to species microhabitat preferences but rather to provide a general description of the site and assist future researchers in locating it, should further surveys take place. Sites on the Nottawasaga River were generally located upstream of CFB Borden, because much of the river below the base, particularly where it passes through Minesing Wetland, is too deep to be waded and is characterized by deeply incised banks (Figure 2). The exception was site NR1-1 in Wasaga Beach, which was sampled on a sandy shoal along the inner bank of the oxbow.

Generally, rubble, gravel and sand constituted the majority of the substrate with means (± standard error) of 19.7 (± 5.7), 34.5 (± 6.4) and 32.5 (± 6.7), respectively. There were only small quantities of boulder at all sites, with a mean of 1.7 (± 1.1). These means represent the data from the 20 sites where the substrate breakdown was recorded and complete (i.e., excludes NR1-4, NR3-3, NR3-4, NR3-7, NR3-8, and NR3-9; see Table 2). The mean depth for the sites sampled was 0.40 m, and the mean site length and mean width ranged from 20-630 m and 4-45 m, respectively (Table 2).

The Nottawasaga watershed is generally characterized by low turbidity; Table 2 shows high water clarity for the majority of the sites (indicating visibility throughout the water column). However, just upstream of NR2-3, the Innisfil Creek confluence brings turbidity into the clear main channel, and sites downstream of NR2-3 were considered highly turbid with poor visibility. At the confluence with Cookstown Creek (upstream of NR4-6), Innisfil had poor water clarity, while Cookstown Creek was clear.

3.2 FRESHWATER MUSSEL COMMUNITY

In total, 581 Unionids from 11 species were found at the 23 sites sampled in the Nottawasaga River watershed (Table 3). These 11 species include all 10 species historically reported from the river (excluding misidentifications; see Table 1 and Introduction) as well as *Elliptio complanata* which had not previously been collected. Mussel distributions were quite patchy and at 12 of the sites no animals were found. The majority of these sites were on the main channel between the Hockley Valley Provincial Nature Reserve, north of Salem, and the Beattie Pinery Provincial Nature Reserve, south of Alliston (Figure 2). Four additional sites (NR2-7, NR3-1, NR3-2 and NR4-6) had fewer than 10 animals present. The site with the highest abundance and species richness was NR1-1, located on the oxbow of the Nottawasaga River in Wasaga Beach, where 275 animals representing seven species were found on a shallow shoal along the inside bank. Site NR4-5 had the next greatest abundance, with 106 animals from four species (Table 3). Species richness was generally low, with only three sites

having five or more species present (NR1-1, NR2-2, NR3-1; see Table 3 and Figure 2).

At least five live animals were found at each of the three sites on Innisfil Creek, with 106 mussels found at one site (NR4-5). The Boyne River was somewhat less productive, with no live animals found at two of the four sites (NR3-3 and NR3-4) and fewer than 10 found at each of the other two sites. Willow Creek was inconsistent, with 44 and 14 mussels found at NR1-4 and NR1-2, respectively, but none at NR1-3. There were no live animals found at the single site sampled on each of the Pine and Mad rivers (NR3-5 and NR3-6, respectively; see Figure 2). Two other sites on Pine River and one on Mad River were scouted but not sampled due to depth (NR3-7), unsuitable habitat (NR3-8), and insufficient time (NR3-9). In addition to these three sites, 11 sites had fewer than 4.5 person-hours of search effort, because few or no animals were found in the first hour of searching (Appendix A).

The distribution and abundance of several of the common species found indicate that these species are established in multiple waterbodies in the watershed. The two most frequently occurring species (Table 4), *Lampsilis siliquoidea* (Fatmucket) and *Anodontoides ferussacianus* (Cylindrical Papershell) were found at 10 and seven sites, respectively, with individuals present in the Nottawasaga River, Boyne River, Innisfil Creek, and Willow Creek. *Strophitus undulatus* (Creeper) was found at five sites and *Lasmigona compressa* (Creek Heelsplitter), and *Lasmigona costata* (Flutedshell) were found at four sites, all in multiple waterbodies, but at fairly low abundances (Table 3).

The species having the greatest frequency of occurrence and relative abundance over the two sampling events was *L. siliquoidea*, which was found at 43.48% of sites (10 of the 23 sites searched), and comprised 55.59% of the total number of animals found in the watershed (Table 4). The species was found at all but one of the 11 sites where unionids were present, varying from a single animal (NR4-6) to 127 animals found (NR1-1; see Table 3). Of the 323 *L. siliquoidea* collected, 201 males and 69 females were identified, making a male to female ratio of 2.9:1. Three animals at NR2-7 and two at NR3-1 were not sexed, and 11 female and 37 male *L. siliquoidea* were not measured at NR1-1, because of the large number of animals found. The *L. siliquoidea* length-frequency distribution, factored by sex, is shown in Figure 3. Maximum length for the males and females were similar: 115 mm for males and 114 mm for females. The mean length of the male *L. siliquoidea* was 77.4 mm and the mean length for females was 69.9 mm.

Elliptio dilatata (Spike) had the next greatest abundance, with 70 animals found, but was limited to just 2 sites (Table 3). The length-frequency distribution for *E. dilatata* is shown in Figure 4. At NR1-1, *E. dilatata* and *Elliptio complanata* (Eastern Elliptio) were found to co-occur, and this was the only site where *E. complanata* was detected.

4.0 DISCUSSION

While the 2009 survey did confirm the presence of 11 species of freshwater mussels in the Nottawasaga River watershed, it did not detect any Species at Risk. Few of the common species found had high relative abundance or frequency of occurrence, with the exception of the dominant *L. siliquoidea*. Of the 26 sites identified in the watershed, 23 were surveyed, and live mussels were identified at only 11 sites. In general, the Nottawasaga River watershed is sparsely populated with unionids, particularly in the Pine, Boyne, and Mad rivers, where few animals were found. The majority of sites with mussels present were on the Nottawasaga River, Innisfil Creek, and Willow Creek. High turbidity did not appear to negatively affect mussel presence, as the only sites with abundances of greater than 50 animals were on Innisfil Creek and the Nottawasaga River downstream of the Innisfil Creek confluence (NR4-5 and NR1-1, respectively; see Table 3). The length-frequency distributions for *L. siliquoidea* and *E. dilatata*, the species for which a sufficient number of animals were found, show multiple strong size classes, providing evidence of reproduction and recruitment (Figures 3 and 4, respectively). Six juvenile *L. siliquoidea* were found at NR2-1 and NR2-2, all less than 60 mm. *Elliptio dilatata* individuals ranged from 38-94 mm, with one animal measuring 112 mm identified at NR2-2.

4.1 *ELLIPTIO DILATATA* (SPIKE) AND *ELLIPTIO COMPLANATA* (EASTERN ELLIPTIO)

The ranges of *E. dilatata* and *E. complanata* overlap in the Nottawasaga River watershed, as demonstrated by their co-occurrence at NR1-1, on the main channel in Wasaga Beach (Table 3, Figure 5). *Elliptio dilatata* is a Mississippian species, commonly distributed throughout southwestern Ontario rivers and streams, while *E. complanata* is an Atlantic slope species more often found throughout lakes and streams of the Ontario Shield, and the rivers of southeastern, eastern, and northeastern Ontario (Metcalfe-Smith et al. 2005, OMNR 2005; see Figures 6 and 7). The presence of both species indicates that the Nottawasaga River is a transitional watershed, representing an important biogeographical area. However, with only 15 *E. complanata* individuals found, and at just one site, it is difficult to determine the status of this species in the Nottawasaga River.

5.0 CONCLUSION

This is the first wide-scale unionid survey of the Nottawasaga River and its tributaries, the Pine, Mad, and Boyne rivers and Innisfil, Willow, and Cookstown creeks. As such, it represents a collection of baseline data, which will be useful as a basis for further work in the watershed. All 10 species that were found historically were found during the current sampling period. One additional

species was also observed, *Elliptio complanata,* bringing the total number of species to 11. Additional surveys are necessary to monitor the survival and reproduction of the 11 species found, and to determine the extent of co-occurrence for *E. dilatata* and *E. complanata* in the watershed.

6.0 ACKNOWLEDGEMENTS

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Table 1. Mussel species occurring in the Nottawasaga River. Unionid data from the Lower Great Lakes Unionid Database (2011).

Species		Nottawasaga River	
		1932-1938	1998-2009
Alasmidonta marginata	Elktoe	X	X
Anodonta implicata[1]	Alewife Floater	X	-
Anodontoides ferussacianus	Cylindrical Floater	X	X
Elliptio complanata	Eastern Elliptio	-	X
Elliptio dilatata[2]	Spike	X	X
Lampsilis cardium[2]	Plain Pocketbook	X	X
Lampsilis radiata[1]	Eastern Lampmussel	X	-
Lampsilis siliquoidea	Fatmucket	X	X
Lasmigona compressa	Creek Heelsplitter	X	X
Lasmigona costata[2]	Flutedshell	X	X
Ligumia recta[2]	Black Sandshell	X	X
Pyganodon cataracta[1]	Eastern Floater	X	-
Pyganodon grandis	Giant Floater	X	X
Strophitus undulatus[2]	Creeper	X	X
Species Richness		**10**	**11**

[1] These are considered erroneous records and are not included in the species richness

[2]Reported by Detweiler 1918

Table 2. Physical characteristics of the sites surveyed in the Nottawasaga River watershed in 2009. Substrate types are modified from Wentworth (1922): boulder is >250 mm in size, rubble is between 60-250 mm in size, gravel is between 20-50 mm in size, and sand is <20 mm in size. "Other" includes muck, silt, and detritus. N/A refers to data that were not collected, and "x" indicates the presence of a characteristic that was not quantified.

	Substrate (%)									Stream morphology (%)			
Site	Boulder	Rubble	Gravel	Sand	Other	Water clarity	Site length (m)	Mean width (m)	Mean depth searched (m)	Riffle	Run	Pool	Flat
NR1-1	0	0	60	40	0	turbid	80	45	0.6	0	100	0	0
NR1-2 [WC]	0	25	25	25	25	clear	200	8	0.3	33	34	33	0
NR1-3 [WC]	0	0	0	100	0	N/A	150	11	0.75	0	100	0	0
NR1-4 [WC]	0	x	x	x	x	good	250	5	0.5	40	20	40	0
NR2-1	10	40	25	15	10	turbid	400	20	0.2	25	40	15	10
NR2-2	0	0	5	95	0	turbid	600	N/A	0.3	5	50	10	25
NR2-3	20	30	10	40	0	turbid	420	20	0.3	0	80	0	20
NR2-4	0	0	25	75	0	clear	200	N/A	N/A	20	50	30	0
NR2-5	0	30	30	40	0	clear	200	15	0.6	40	10	50	0
NR2-6	0	65	30	5	0	clear	150	15	N/A	20	30	10	40
NR2-7 [IC]	0	0	0	50	50	very turbid	N/A	N/A	N/A	0	0	50	50
NR3-1 [BR]	0	0	50	40	10	clear - turbid	20	11	0.6 - 0.75	10	90	0	0
NR3-2 [BR]	0	0	95	0	5	clear	60	6	0.3	5	95	0	0
NR3-3 [BR]	x	0	x	0	0	clear	N/A	9	0.3	x	x	0	0
NR3-4 [BR]	0	0	0	0	0	clear	30	5	0.3	N/A	N/A	N/A	N/A
NR3-5 [PR]	0	0	60	40	0	clear	135	8	0.75	10	90	0	0
NR3-6 [MR]	4	4	90	0	2	clear	100	14.5	0.4	95	0	5	0
NR3-7	0	0	x	x	0	N/A	N/A	N/A	N/A	x	x	0	0
NR3-8	x	x	0	x	0	clear	N/A	13.5	N/A	N/A	N/A	N/A	N/A
NR3-9	0	x	x	0	0	clear	N/A	N/A	N/A	x	x	0	0
NR4-1	0	90	5	5	0	good	412	4	0.2	100	0	0	0
NR4-2	0	45	45	10	0	> 1m	425	15	0.4	80	0	20	0
NR4-3	0	35	50	5	10	2m	630	12	0.2	80	0	20	0
NR4-4	0	25	60	10	5	N/A	345	10	0.4	40	0	60	0
NR4-5 [IC]	0	5	20	10	65	1m	180	5	0.4	25	25	25	25
NR4-6 [IC]	0	0	5	45	50	turbid - clear	160	5	0.4 - 0.5	0	100	0	0

[WC] represents sites in Willow Creek, [IC] in Innisfil Creek, [BR] in Boyne River, [PR] in Pine River, [MR] in Mad River

Table 3. Number of live specimens collected at each of the 23 sites surveyed in the Nottawasaga River watershed in 2009 by Fisheries and Oceans Canada. NR3-7, NR3-8, NR3-9 are not included, as they were not searched.

Site	*Alasmidonta marginata*	*Anodontoides ferussacianus*	*Elliptio complanata*	*Elliptio dilatata*	*Lampsilis cardium*	*Lampsilis siliquoidea*	*Lasmigona compressa*	*Lasmigona costata*	*Ligumia recta*	*Pyganodon grandis*	*Strophitus undulatus*	Total	Species Richness
NR1-1	-	-	15	68	21	127	-	24	17	-	3	**275**	**7**
NR1-2[WC]	-	3	-	-	-	10	-	-	-	1	-	**14**	**3**
NR1-3[WC]	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR1-4[WC]	-	28	-	-	-	2	14	-	-	-	-	**44**	**3**
NR2-1	1	-	-	-	-	12	-	-	-	-	3	**16**	**3**
NR2-2	3	3	-	2	-	53	-	3	-	-	7	**71**	**6**
NR2-3	1	-	-	-	1	24	-	1	-	-	-	**27**	**4**
NR2-4	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR2-5	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR2-6	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR2-7[IC]	-	5	-	-	-	3	-	-	-	-	-	**8**	**2**
NR3-1[BR]	-	1	-	-	-	2	1	1	-	-	3	**8**	**5**
NR3-2[BR]	-	-	-	-	-	-	1	-	-	-	6	**7**	**2**
NR3-3[BR]	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR3-4[BR]	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR3-5[PR]	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR3-6[MR]	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR4-1	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR4-2	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR4-3	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR4-4	-	-	-	-	-	-	-	-	-	-	-	**0**	**0**
NR4-5[IC]	-	6	-	-	-	89	6	-	-	5	-	**106**	**4**
NR4-6[IC]	-	4	-	-	-	1	-	-	-	-	-	**5**	**2**
Total	**5**	**50**	**15**	**70**	**22**	**323**	**22**	**29**	**17**	**6**	**22**	**581**	

[WC] represents sites in Willow Creek
[IC] represents sites in Innisfil Creek
[BR] represents sites in Boyne River
[PR] represents sites in Pine River
[MR] represents sites in Mad River

Table 4. Abundance and frequency of occurrence of all mussel species observed in the Nottawasaga River watershed in 2009.

Species		Abundance	Relative Abundance (%)	Frequency of Occurrence (%)
Alasmidonta marginata	Elktoe	5	0.86	13.04
Anodontoides ferussacianus	Cylindrical Papershell	50	8.61	30.43
Elliptio complanata	Eastern Elliptio	15	2.58	4.35
Elliptio dilatata	Spike	70	12.04	8.70
Lampsilis cardium	Plain Pocketbook	22	3.79	8.70
Lampsilis siliquoidea	Fatmucket	323	55.59	43.48
Lasmigona compressa	Creek Heelsplitter	22	3.79	17.39
Lasmigona costata	Flutedshell	29	4.99	17.39
Ligumia recta	Black Sandshell	17	2.93	4.35
Pyganodon grandis	Giant Floater	6	1.03	8.70
Strophitus undulatus	Creeper	22	3.79	21.74

Figure 1. Location of the Nottawasaga River watershed as well as the Maitland and Ausable rivers.

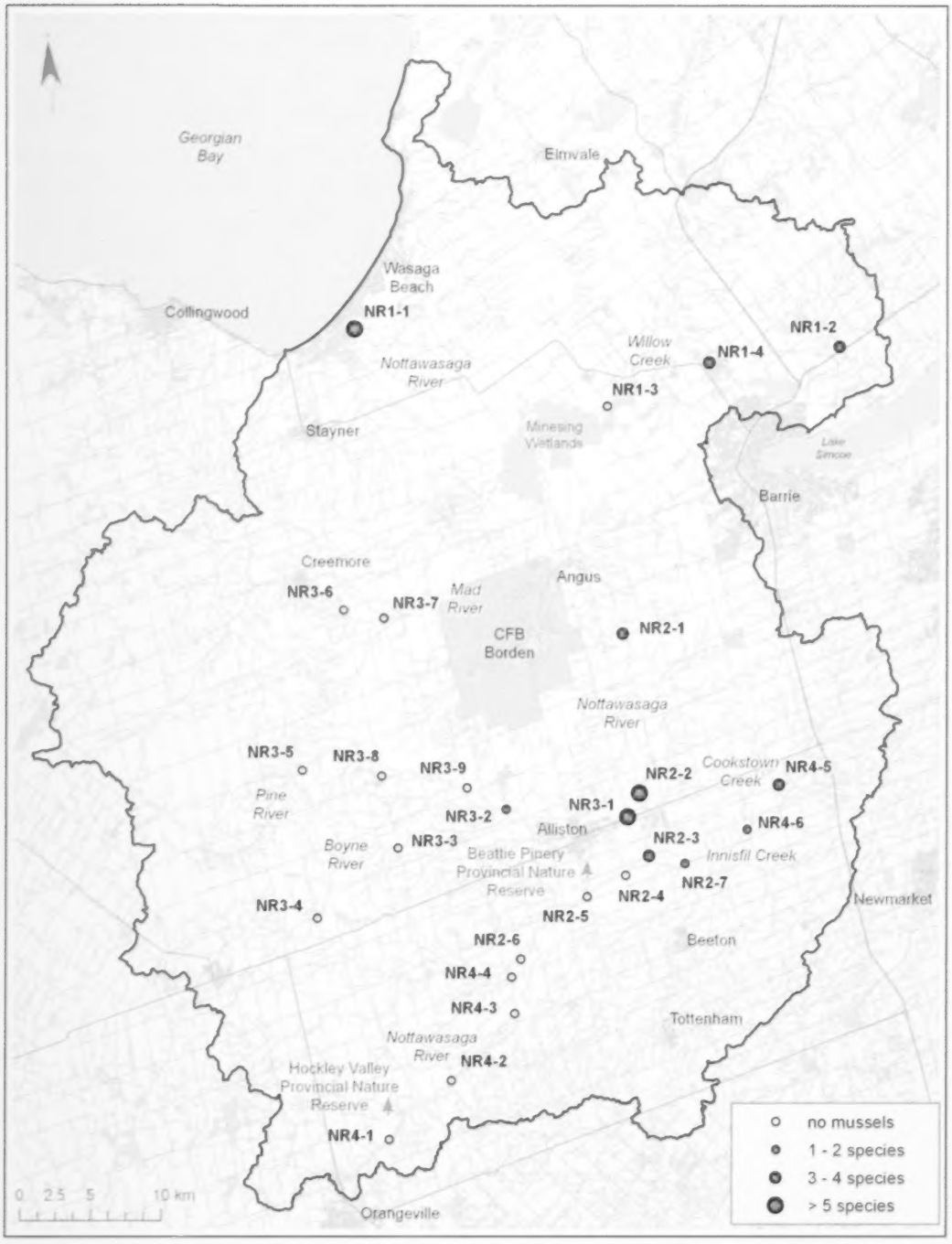

Figure 2. Twenty-six sites surveyed in July 2009 on the Nottawasaga River, Willow and Innisfil creeks, and the Boyne, Pine, and Mad rivers. Circle size indicates species richness at each site. NR3-7, NR3-8, and NR3-9, were not surveyed. Site number corresponds to numbers in the tables and appendix.

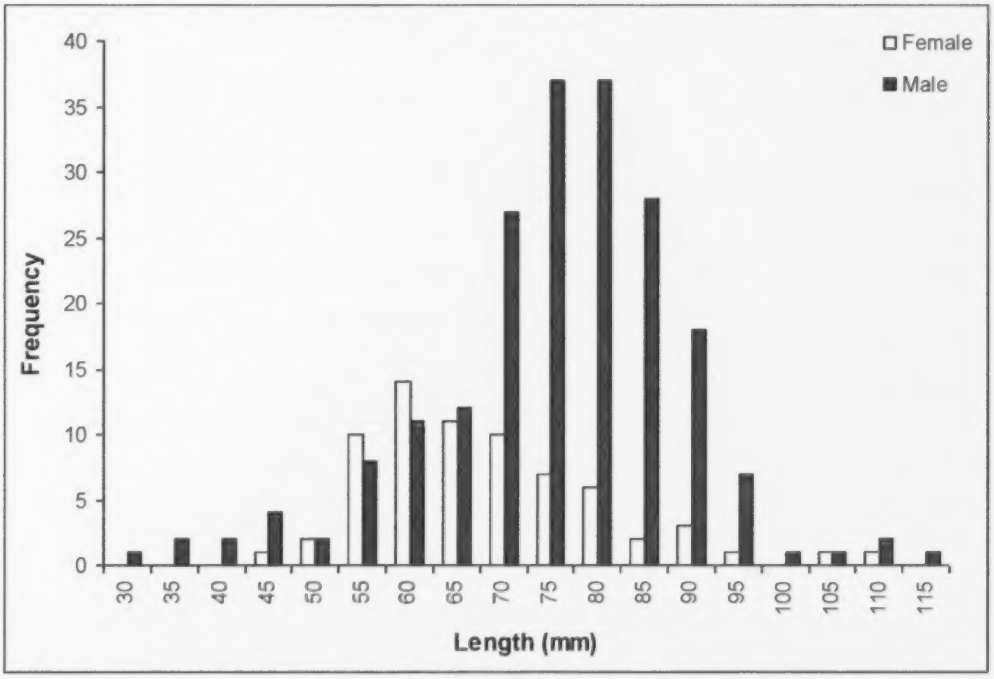

Figure 3. Length frequency distribution of male (n = 201) and female (n = 69) *Lampsilis siliquoidea* (Fatmucket) found and sexed in the Nottawasaga River watershed in 2009.

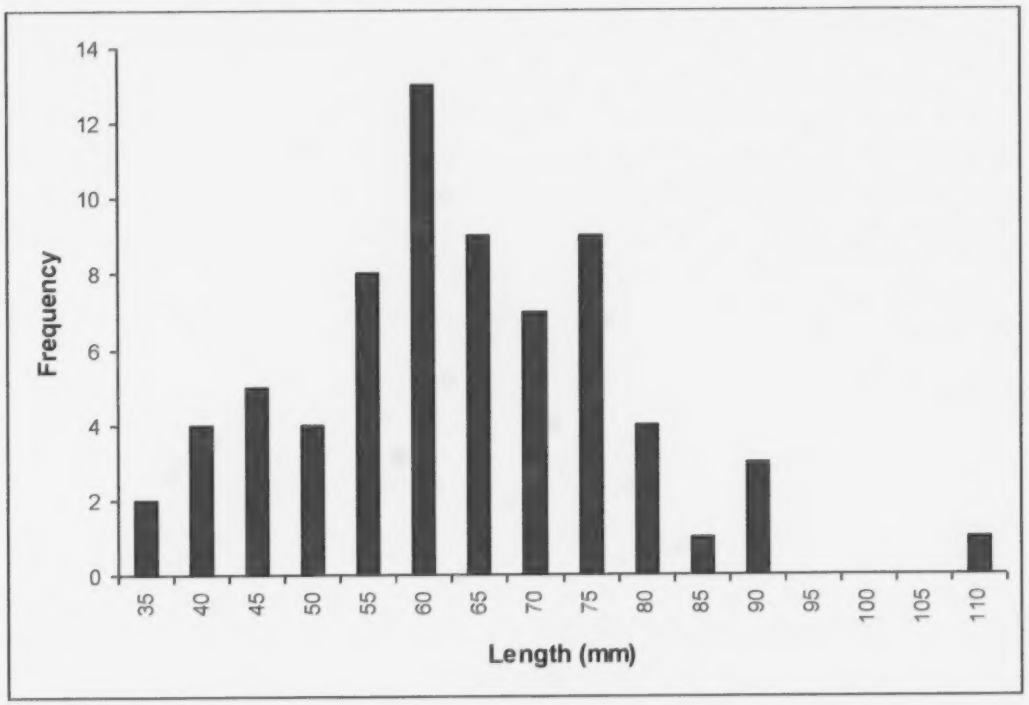

Figure 4. Length frequency distribution of *Elliptio dilatata* (Spike) found in the Nottawasaga River watershed in 2009 (n = 70).

Figure 5. *Elliptio complanata* (top four specimens) and *Elliptio dilatata* (bottom four specimens) found at site NR1-1 in Wasaga Beach in the Nottawasaga River watershed on July 7, 2009.

Figure 6. Map of Canadian waterbodies demonstrating the geographic range of *Elliptio complanata*, an Atlantic Slope species found in the Nottawasaga River watershed in July 2009.

Figure 7. Map of Canadian waterbodies demonstrating the geographic range of *Elliptio dilatata*, a Mississippian species found in the Nottawasaga River watershed in July 2009.

Appendix A. Locations of all sites identified and surveyed in Nottawasaga River watershed in 2009 by Fisheries and Oceans Canada. Site descriptions and effort (number of person hours searched) are included.

Site	Date	Latitude	Longitude	Waterbody	Watershed	Local Description	Effort	Collectors
NR1-1	07/07/09	44.48097	-80.04398	Nottawasaga River	Nottawasaga River	Sandy shoal on west bank of oxbow; access via Knox Rd	4.50	Morris, Robinson, den Haas, Ockenden, Halliday
NR1-2	07/07/09	44.44903	-79.61251	Willow Creek	Nottawasaga River	Willow Creek at 2nd Line	4.50	Morris, Robinson, den Haas, Ockenden, Halliday
NR1-3	08/07/09	44.42178	-79.82349	Willow Creek	Nottawasaga River	George Johnston Rd, edge of Minesing Swamp	4.50	Morris, Robinson, den Haas, Ockenden
NR1-4	08/07/09	44.44459	-79.72984	Willow Creek	Nottawasaga River	Findley Mill Rd bridge	4.50	Morris, Robinson, den Haas, Ockenden
NR2-1	07/07/09	44.27836	-79.82275	Nottawasaga River	Nottawasaga River	End of trail at end of 20th Sideroad, near trailer park	4.50	McGoldrick, Minke-Martin, Gibson, Claydon, Ferguson
NR2-2	07/07/09	44.17746	-79.81715	Nottawasaga River	Nottawasaga River	Crossing on 5th Line between Hwy 89 & 5th Sideroad	4.50	McGoldrick, Minke-Martin, Gibson, Claydon, Ferguson
NR2-3	07/07/09	44.13766	-79.81224	Nottawasaga River	Nottawasaga River	13th Line, S of Hwy 89	4.50	McGoldrick, Minke-Martin, Gibson, Claydon, Ferguson
NR2-4	08/07/09	44.12648	-79.83430	Nottawasaga River	Nottawasaga River	Tottenham Rd Crossing	2.50	McGoldrick, Minke-Martin, Gibson, Claydon, Ferguson
NR2-5	08/07/09	44.11456	-79.86948	Nottawasaga River	Nottawasaga River	Adjala-Tecumseh Line Crossing	1.25	McGoldrick, Minke-Martin, Gibson, Claydon, Ferguson
NR2-6	08/07/09	44.07839	-79.93185	Nottawasaga River	Nottawasaga River	Crossing on 4th Line	1.25	McGoldrick, Minke-Martin, Gibson, Claydon, Ferguson
NR2-7	08/07/09	44.13118	-79.78095	Innisfil Creek	Nottawasaga River	2nd bridge on 12th Line	2.92	McGoldrick, Minke-Martin, Gibson, Claydon, Ferguson
NR3-1	07/07/09	44.16318	-79.82893	Boyne River	Nottawasaga River	Hwy 10, just north of Hwy 89. Downstream of bridge	3.33	McNichols, Sagan, Fortini, Johansson
NR3-2	07/07/09	44.17278	-79.93648	Boyne River	Nottawasaga River	Hwy 13 crossing, near Earl Rowe Provincial Park	4.50	McNichols, Sagan, Fortini, Johansson
NR3-3	07/07/09	44.15307	-80.03432	Boyne River	Nottawasaga River	Hwy 18 between Hwy 17 & 5th Sideroad	2.75	McNichols, Sagan, Fortini, Johansson
NR3-4	07/07/09	44.11255	-80.10972	Boyne River	Nottawasaga River	1st Line, most Southern of 4 bridges	1.50	McNichols, Sagan, Fortini, Johansson
NR3-5	07/07/09	44.2059	-80.115164	Pine River	Nottawasaga River	upstream and downstream of bridge crossing on 2nd Line near Terra Nova	2.25	McNichols, Sagan, Fortini, Johansson

Appendix A Continued.

Site	Date	Latitude	Longitude	Waterbody	Watershed	Local Description	Effort	Collectors
NR3-6	08/07/09	44.30471	-80.06960	Mad River	Nottawasaga River	Sideroad 3 & 4 off of Hwy 42	3.00	McNichols, Sagan, Fortini, Johansson
NR3-7	08/07/09	44.2981	-80.03426	Mad River	Nottawasaga River	Bridge Crossing on Center-Line Road, West of Glencairn	0.00	McNichols, Sagan, Fortini, Johansson
NR3-8	08/07/09	44.199	-80.045	Pine River	Nottawasaga River	Hwy 18 (Airport Rd.) between Sideroads 15 and 17	0.00	McNichols, Sagan, Fortini, Johansson
NR3-9	08/07/09	44.188	-79.97	Pine River	Nottawasaga River	Concession Rd 3, North of Hwy 5, near Everett	0.00	McNichols, Sagan, Fortini, Johansson
NR4-1	20/07/09	43.97075	-80.05827	Nottawasaga River	Nottawasaga River	Hwy 7 (Hockley Rd) & 2nd Line EHS	4.50	Morris, Robinson, Sagan, Minke-Martin
NR4-2	20/07/09	44.00514	-79.99979	Nottawasaga River	Nottawasaga River	Hwy 18 (Airport Rd.), 100m north of Hwy 7 (Hockley Rd.)	4.50	Morris, Robinson, Sagan, Minke-Martin
NR4-3	20/07/09	44.04447	-79.94022	Nottawasaga River	Nottawasaga River	Concession #3, County Rd. 1, E. of Hockley	4.50	Morris, Robinson, Sagan, Minke-Martin
NR4-4	20/07/09	44.06749	-79.94087	Nottawasaga River	Nottawasaga River	Adjala 20 Sideroad bridge crossing	2.66	Morris, Robinson, Sagan, Minke-Martin
NR4-5	21/07/09	44.1765	-79.69290	Innisfil Creek	Nottawasaga River	Innisfil Rd. 14	4.50	Morris, Robinson, Sagan, Minke-Martin
NR4-6	21/07/09	44.14989	-79.72401	Innisfil Creek	Nottawasaga River	20th Sideroad @ confluence with Cookstown Cr.	2.66	Morris, Robinson, Sagan, Minke-Martin